Reduction of Harmful Emissions by the Odessa Combined Heat and Power Plant

Project Title: Development of the Comprehensive Program for Reduction of Harmful Emissions into the Atmosphere by the Odessa Central Heating and Power Plant 2
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Location of Project: Teplodar, Odessa Region, Ukraine
Project Duration: September 2000 - May 2001
EcoLinks Project Support: EcoLinks grant support: $43,898; Project Team cost-share contribution $19,530.

Best Practice: Transferable Solutions

The project "Improving the Environmental Performance of Odessa CHPP Heat Boilers" is an EcoLinks Best Practice. It illustrates the environmental and financial benefits that can be achieved through relatively low-cost efficiency improvements at heat utility plants in the NIS. In this case, the heat utility plant dramatically improved its environmental performance while reducing heat production costs by more than 50%. The project shows the value of taking a systematic approach to improving energy efficiency, and in identifying both high and low cost measures which can be implemented as funding allows. The methodology for conducting energy and environmental audits and for development of a feasibility study comparing various

scenarios can be used by other heat utilities in the NIS. The methodology will be particularly transferable for heat utilities with boilers which generate super-saturated steam and for heat utilities considering the introduction of co-generation.

Project Summary

The heat-only boiler plant (HOBP) in Teplodar was originally constructed for the commissioning of a planned 2-reactor nuclear heat and power plant at Teplodar. Plans to build the nuclear plant in Teplodar were abandoned after the Chernobyl accident in 1986, and the HOBP remains the only heat source for more than 10,000 inhabitants, commercial consumers and public services in the area. Since the HOBP was originally planned to be used only during the commissioning of the nuclear power plant, even the environmental requirements that were in place at the time of the HOBP's construction were not observed (for example, the HOBP has a very short-stack chimney, only 40 meters high).

Prior to project implementation, the HOBP ran on bunker fuel oil and the boiler and heat distribution systems of HOBP did not run efficiently. Consequently, HOBP was a very heavy polluter, and emissions greatly exceeded permissible limits. Prior to project implementation, annual emissions from the HOBP were estimated at 38 tons of CO, 89 tons of NO_x, 7 tons of ash, 371 tons of SO_2 and 4 tons V_2O_5.

The goal of this project was to develop a comprehensive strategy to reduce these emissions by improving energy efficiency at the HOBP. An audit of the current energy flows at the HOBP and in the heat distribution network was conducted, including an audit of selected end-users and an estimation of energy savings potential. Training for plant managers in monitoring heat production and in conducting energy audits was also carried out. Based on the results of the energy audit, project experts developed a feasibility study for suggested efficiency improvements at the HOBP. A final product of this project was a fully developed Action Plan for energy efficiency improvements at HOBP.

Using the findings and recommendations developed in this project, HOBP management was able to demonstrate to the Odessa regional government administration the significant environmental improvements and cost savings that could be achieved through a fuel switch from bunker fuel to natural gas. The Odessa regional government administration contributed $460,000 to carry out this fuel switch on two of the four boiler units and HOBP management has contributed Plant resources to carry out several smaller efficiency measures. The economic and environmental impact of these energy efficiency measures has been significant: SO_2 ash and V_2O_5 have dropped to virtually zero, CO and CO_2 emissions have been reduced by 70 % and 20% respectively compared with pre project levels, while HOBP's cost for producing a unit of heat at has dropped by about 50%.

Project Activities

The goal of this project was to develop a comprehensive strategy to reduce emissions at HOBP by improving energy efficiency. The project activities included the following:

1. Energy and Environmental Audits of Teplodar HOBP

Action: The project team calculated the energy balance at the HOBP and in the district transmission network, the central heat exchangers, and the heat distribution network. Energy losses in selected end user apartment buildings and commercial enterprises were also estimated. During the energy audit process, auditors also calculated or estimated pollutants resulting from the HOBP and district heat network.

Findings of the energy audit showed that: (1) Over 11% of energy is lost in the two-step process of heat production (production of steam in the boilers which is then converted to hot water). (2) About 7% of energy input to the plant is lost through inefficiencies in the heat supply needed for various processes in the boiler room (including preparation of bunker fuel for burning). An additional 5% of the total energy input to the plant is lost through inefficiencies in heat supply at the plant site (losses from heating plant buildings, etc). (3) There are significant power losses in the transformation process (from high voltage to low voltage) of electricity, which the plant purchases for its own energy consumption needs. (4) Energy losses in the heat transmission pipe line and hot water and heat distribution network equal almost 25%. This is partly due to the over-sized capacity of the district network (for its current use of supplying heat and hot water to 10,000 residential users) and partly due to poor thermal insulation of district heat pipes and heat exchangers. Total energy losses from the Teplodar HOBP heat production, transportation and distribution equal more than 47%.

Findings of the environmental audit showed that the type of fuel used at the Teplodar HOBP, bunker fuel (which is a heavy fuel oil high in sulfur content), resulted in annual emissions of 371 tons of sulfur oxides and 89 tons of nitrogen oxide, as well as V_2O_5 emissions and other heavy metals.

As a result of these findings, the Project Team developed no, low, medium and high-cost measures to reduce energy losses in the district heating system and to improve environmental performance.

> No-and Low-Cost Measures: The project team recommended conducting an awareness and information campaign to explain to end users no-cost measures to reduce energy losses in their homes, such as the optimal level of humidity in apartments, etc. The project team identified basic insulation measures in apartment buildings, such as sealing windows and installing aluminum foil behind radiators installed in external walls as the low-cost measures with the highest potential energy savings. Estimated simple pay back period for all no-and low-cost measures is less than two years.
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> Medium-Cost Measures: Medium-cost measures identified by the Project Team focused on the plant boilers, the district-heating network and on end-users buildings. Recommendations included installing metering devices in end-user buildings where possible; regularly monitoring the efficiency in the boilers and consumption and losses throughout the system; and closing off hot water pipes in the HOBP and district heating network which are no longer used. Estimated pay back period for these medium-cost measures is less than two years. The Project Team also recommended a series of more expensive insulation and sealing measures (such as insulating buildings) on end-user buildings, which could be financed by the municipal authorities.

High-Cost Measures: High-cost measures focus mostly on rehabilitation/modernization measures. Recommended high-cost rehabilitation measures include: modernizing boilers at the Teplodar plant; repairing and replacing the heat main pipe from the Teplodar plant to the city and distribution pipe within the city; rehabilitating of the heating system in end-user buildings; carrying out a fuel switch at HOBP from bunker fuel to natural gas; installing steam turbines at the plant; and replacing district tap water heating system with local tap water heating, through heat exchanges located in individual buildings. Estimated simple pay back period for all of these measures is less than five years, with the exception of replacement of the district tap water system, which has a pay back period of 12 years.

Product(s): 1) Energy and environmental audit of the HOBP and district heat network produced completed. 2) No, low, medium and high-cost measures to reduce energy losses and to improve environmental performance were developed.

2. Training of HOBP Staff in Metering Equipment, Estimating Energy Use/losses and Conducting an Energy Audit

Action: The Project Team trained Teplodar HOBP staff to use the methodology applied within project implementation to measure or estimate energy use and loss throughout the system. This training included use of special equipment, such as the infrared thermometer as well as appropriate computer programs, such as TERMIFLOW. Selected staff were also trained in conducting an environmental audit, and in the methodology of cost benefit analysis, including the benefits of using FINPLAN software.

Product(s): 1) Increased capacity of HOBP staff to monitor energy efficiency/losses.
2) Selected HOBP staff trained to conduct an environment audit and cost/benefit analysis.

3. Development of a Feasibility Study Comparing 5 Possible Scenarios at HOBP

Action: The project team developed five scenarios for reducing energy losses at the HOBP. These included (1) Decommissioning of the HOBP and replacing it with a large, co-generation plant; (2) Optimization of existing HOBP operation, combined with installation of steam turbines (which would allow for co-generation); (3) Decommissioning of the HOBP, replacing it with small co-generation plants located closer to end users; (4) Replacement of the district heating system with local heating systems in Teplodar city; (5) Replacement of the district heating network with local heating systems.

Economic and environmental analysis was done for each scenario. The Project Team, together with the HOBP management decided that Option #2 "Optimization of existing HOBP operation combined with installation of steam turbines (which would allow for co-generation)" was the most attractive in the near-term future. The Project Team recommended that this option be implemented in tandem with energy efficiency improvements in the heat transmission and distribution networks and in end user buildings for maximum effect.

Product(s) 1) Feasibility study on reducing energy losses at the HOBP produced.

4. Fuel Switch from Bunker Fuel to Natural Gas at the Teplodar HOBP

Action: A critical step in realizing Option #2 at the HOBP was making a fuel switch from bunker fuel to natural gas, which would result in significant cost savings and greatly improve the environmental performance of the HOBP. Further, this fuel switch is a critical precursor for the installation of steam turbines and thus for co-generation at the HOBP. With data and findings developed through this EcoLinks funded project, the Project Team was able to demonstrate and quantify these benefits, and the regional government of Odessa contributed $460,000 to carry out this fuel switch on two of Teplodar's four boilers. The switch was completed in December 2000 and involved reconstruction of fuel and burning systems in two boilers, laying 1600 meters of pipe, installing three gas compressor stations and building a new distribution system inside the HOBP.

Product(s): 1) Fuel switch from bunker fuel oil to natural gas at two on the HOBP's four boilers.

5. Installation of New Heat Transport Piping System to Administration Buildings on HOBP Territory

Action: New heat transport pipes between the boilers and the administration buildings at the HOBP site were installed. The pipes are more direct than the previous heat transport system and better insulated. The approximate cost of this work was $5,000 and it was paid for by Teplodar HOBP.

Product(s): New heat transport pipes installed to HOBP administrative buildings.

6. Development of an Action Plant for Implementing Efficiency Measures

Action: The Project Team developed an Action Plan outlining major recommended energy saving measures, their costs, benefits, potential funding sources and estimated timetable for implementation. Measures focused on five potential areas of energy conservation: decreasing consumption and losses in the Plant; reducing thermal losses in the heat main network; reducing thermal losses in the heat distribution network; reducing thermal losses in the hot tap water heating and distribution network; reducing thermal losses in end-user buildings. Total cost for rehabilitating the HOB district heating network and implementing recommended energy saving measures is approximately $1.4 million. All but one of the recommended measures have simple payback period of between several months to five years.

This Action Plan was presented to the Odessa Regional Council in March 2001. The Odessa Regional Council showed much interest in supporting the public awareness raising measures in the near-term future and also interest in financing the purchase of one gas turbine to allow for co-generation in 2003.

Product(s): An Action Plan outlining major recommended energy saving measures, their costs, benefits, potential funding sources and estimated timetable for implementation was developed.

Follow-up Activities

Near-term follow up activities include the preparation of a business plan for selected measures, which will be presented to the Odessa Regional Council by the end of 2001. Measures highlighted in the business plan will include the purchase and installation of a steam turbine and connection of the boilers to the 120m chimney. The Plant also plans to undertake some of the recommendations on reconstruction/repair of boiler units to optimize steam production and in the piping system on Plant territory to reduce heat losses, using the Plant's own resources.

In the longer-term, the management of Teplodar's HOBP will develop a strategic plan of measures to be implemented, including rehabilitation and insulation of the main heat pipe from the HOBP to Teplodar city pipes, rehabilitation of the hot tap water heating and distribution network, and consistent monitoring of energy loss and use throughout the system. The management of the Teplodar HOBP will also assist Teplodar government authorities in preparing a public awareness campaign on household energy savings measures.

Project Benefits

This project resulted in environmental, economic and capacity building benefits. Capacity building benefits were realized through training for HOBP staff in how to monitor energy use/losses and how to conduct an energy audit. Environmental benefits include significantly reduced emissions and reduced water use, achieved through the fuel switch to natural gas and other energy efficiency measures. Finally, this project also brought significant monetary benefits, through cost savings resulting from more the efficient use of natural resources.

Capacity Building Benefits

Within the implementation of this project, HOBP staff gained experience in conducting energy and environmental audits and in analysis of audit results. This experience included both methodology and data collection, as well as the use of measurement instruments, including an infrared thermometer and metering equipment. Selected HOBP staff were also trained to develop a feasibility study/cost benefit analysis and computer soft ware tools.

Environmental Benefits

Environmental Benefits of Completed Measures

Measures completed within this project include the fuel switch from bunker fuel to natural gas and subsequent decommissioning of the old fuel oil handling system.

Fuel switch to natural gas on two boiler units: total cost $460,000 (Completed)

Pollutant	**Pre-project emission**	**Post-project emission**
CO	38 tons per year	12.9 tons per year
SO_2	371 tons per year	0 tons per year
V_2O_5	3.6 tons per year	0 tons per year
NOx	89.3 tons per year	91.5 tons per year
Ash	6.6 tons per year	0 tons per year

Furthermore, the fuel switch to natural gas has also resulted in an annual water savings of about 2,500 m^3, mostly as a result of the decommissioning of *the* old oil handling system.

Environmental Benefits of Planned Measures

Additional priority measures identified in the feasibility study include repair of the boiler units to optimize steam production, repair (and in some cases decommissioning or replacement) of the piping system on Plant territory to reduce heat losses, installation of metering equipment to measure fuel and steam consumption and heat supply throughout the system. Implementation of these measures will result in increased efficiency and additional reductions in CO, CO_2, NOx and water consumption.

Economic Benefits

The economic benefit of the switch from bunker fuel to natural gas includes cost savings in fuel purchase, transport, handling/storage and preparation. One unit of heat produced from natural gas at Teplodar costs less than half of a unit of heat produced from bunker fuel, and this equals an annual costs savings of almost $200,000. This fuel switch also allows for the possibility for Teplodar to produce its own electricity (after the installation of a steam turbine), which it will be able to produce at about half the cost of buying electricity from the power distribution company. Expected payback time of the fuel switch on two boilers is 2-2.5 years.

The cost of additional priority measures (focusing on repair/reconstruction of boiler units, of the piping network on Plant territory and installation of metering equipment) recommended in the feasibility study is estimated at $175,000. These measures have a payback period of less than 5 years.

Lessons Learned

This project demonstrates that, while municipalities in NIS do have modest funds to support project implementation, in many cases they lack reliable data or well developed feasibility studies which project the costs and benefits of environmental investment projects. The Odessa CHPP-2 Project Team was able to attract significant funding from the Odessa regional government administration because they were able to clearly demonstrate both the environmental and financial benefits of project implementation.

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